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Mathematics for Nurses

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Published by
Teachers College, Columbia University
New York City
1918

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Mathematics for Nurses

Nature of the Problems. The problems given in this pamphlet relate chiefly to the making of solutions of drugs and to the calculation of doses. They are such as arise in the daily experiences of nurses and the directions for their solution are made as simple as possible. A type problem is stated, it is then worked out in the simplest manner, it is occasionally worked out again in an alternative way that may seem more simple to the student, such rules or suggestions as may be helpful to the student are added, and finally a set of exercises is given on the facing page.

Mathematics Presupposed. Since it is hardly probable that any one ignorant of the rudiments of algebra will undertake this work, the algebraic formula and the simple equation in one unknown will be used whenever there is an advantage in so doing. Provision is made for a review of the necessary algebra before these applications are introduced.

Tables. At the end of the pamphlet there will be found such labor-saving tables as the nurse will need in her ordinary computations. It should be understood that tables are used in connection with most of the practical numerical problems involving the making of

Apothecaries' Measures. The United States Pharmacopœia uses the metric system of measures, but in prescribing medicines it is still a general custom in the United States, Great Britain, and the British possessions to use the old system of apothecaries' measures.

The following is the table of apothecaries' weight:

20 grains (gr.)	= 1 scruple (sc. or ℈)
3 scruples	= 1 dram (dr. or ʒ)
8 drams	= 1 ounce (oz. or ℥)
12 ounces	= 1 pound (lb.)

The following is the table of apothecaries' fluid measure:

60 minims (♏)	= 1 fluidram (f. ʒ)
8 fluidrams	= 1 fluidounce (f. ℥)
16 fluidounces	= 1 pint (O)
8 pints	= 1 gallon (cong.)

The following household equivalents are, unfortunately, still in common use, the drop and minim being particularly inexact:

1 drop (gtt.)	= 1 minim
1 teaspoonful	= 1 fluidram
1 dessertspoonful	= 2 fluidrams
1 tablespoonful	= ½ fluidounce
2 fluidounces	= 1 wineglass
6 fluidounces	= 1 teacup
8 fluidounces	= 1 glassful

In writing prescriptions physicians use the Roman numerals for apothecaries' measures and the common numerals for metric measures. They often use the medieval forms for Roman numerals, as in the case of $\overline{\text{viij}}$ or viij for eight, and *ss* for ½. On account of the confusion of grain and gr. with gram and g., the United States Pharmacopœia advises using the French spelling *gramme* and the abbreviation Gm.

For a further list of abbreviations, see page 30.

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Exercise. Apothecaries' Measures

1. A physician's prescription calls for gr. xl of sodium bicarbonate. This is what part of an ounce?

Read the following:

2. ℥ ij **4.** f. ℥ ss **6.** ♏ xxiv **8.** ℥ iv **10.** gr. xliv

3. ♏ viij **5.** f. ℥ iij **7.** ℥ xviij **9.** gr. xxx **11.** ℥ ijss

12. From the list on page 30 write out in full English form, except for the drugs, the meaning of the following prescription:

℞

Antipyrinae	gr. xlvj
Sodii bromidii	℥ ij
Codeinae	gr. iv
Aq. destil. q. s. ad	℥ iv
M. et Sig.	℥i. p. c.

13. Similarly, write out the following in full English form:

℞

Antipyrinae	gr. xlviij
Sodii bromidii	℥ ij
Codeinae	gr. v
Syr. rubi idaei	℥ ij
Aq. destil. q. s. ad	℥ iv
M. et Sig.	℥i. q. 4 h.

Write in full English form the meaning of each of the following:

14. Extracti belladon. gr. ijss.

15. Pil. No. xxij.

16. Opii gr. vij.

17. Pil. Quin. bisulph. āā gr. ij.

18. ℞ pil. No. ij Stat.

19. Pil. Ferri āā. gr. iiss.

Metric System. Since both the metric and apothecaries' systems are used in hospitals, although the latter is gradually being replaced by the former, the nurse must be familiar with both systems. For the purposes of administering medicines, the possible work in hospitals abroad, and the needs of travel, and in other matters relating to nursing, however, it will be found that only a small part of the metric system need be learned.

Metric Prefixes. The language of the metric system is much more simple than it seems at first sight. Of the prefixes that the nurse needs, milli- means $\frac{1}{1000}$ (compare our mill, which is $\frac{1}{1000}$ of a dollar); centi- means $\frac{1}{100}$ (compare our cent); deci- means $\frac{1}{10}$ (compare our word decimal); hekto- means 100 (each begins with h); kilo- means 1000. These prefixes must be known thoroughly.

Metric Lengths. The unit of length in the metric system is the meter (French *mètre*), which is approximately 1 yard, more nearly 39.37 inches.

1 kilometer (km.) = 1000 meters = 0.62 mile
1 meter (m.) = 39.37 in. = nearly 1.1 yd.
1 centimeter (cm.) = 0.01 m. = nearly 0.4 in.
1 millimeter (mm.) = 0.001 m.

The decimeter (0.1 m., about 4 in., the length of the middle finger) is not so often used by name as the above measures.

For work abroad the nurse should be able to visualize 1 km. In a city where there are 20 blocks to a mile, it is 12 blocks.

Metric Areas. A square millimeter is the area of a square that is 1 mm. on a side, and so for a square meter.

Metric Volumes. A cubic millimeter (cmm.) is the volume of a cube that is 1 mm. on an edge, and so for a cubic centimeter (C. c.) and a cubic meter.

These abbreviations, while not uniform, are used by physicians.

Problems. Metric System

1. Look at the following words in order and state aloud the English meaning:

milli-	kilo-	deci-	hekto-	centi-	milli-
hekto-	centi-	milli-	kilo-	deci-	hekto-

Continue this drill until the numerical equivalents can be stated instantaneously. Thus, when you see milli-, say 'thousandth'.

2. Look at the following numbers in order and state aloud the metric prefixes:

0.1	0.01	100	0.001	1000	0.1
100	0.1	1000	0.01	0.001	100

Continue this drill until the metric prefixes can be stated instantaneously. Speak the words aloud so as to train the ear as well as the tongue and eye.

3. A hospital is 12.3 km. behind the firing line. How many miles is this?

Since 1 km. = 0.62 mi.,

12.3 km. = 12.3 × 0.62 mi.

= 7.6 mi. approximately.

If $\frac{3}{5}$ mi. or 0.6 mi. is taken for 1 km., the result will be near enough for most purposes.

You will frequently need to reduce kilometers to miles.

Reduce the following to miles:

4. 18.2 km. **5.** 25.4 km. **6.** $8\frac{3}{4}$ km.

7. A roll of cheesecloth has 100 m. How many yards are there?

8. How many meters are there in 100 yd.?

9. A bandage is 0.1 m. wide. Express this in millimeters.

10. A hospital ward is 20 m. by 40 m. In order to visualize this more clearly, express the dimensions roughly in feet.

Metric Weights. The unit of weight in the metric system is the gramme. It is practically the weight of 1 cubic centimeter of water.

1 kilogramme (Kg.) = 1000 grammes
1 gramme (Gm.) = 15.43 grains
1 milligramme (mg.) = 0.001 Gm.

The abbreviations here used are those of the United States Pharmacopœia.

The decigramme (0.1 Gm.) and centigramme (0.01 Gm.) are not so often used by name as the above measures. The kilogramme is usually called a kilo. It is equivalent to 2.2 avoirdupois pounds or 2.67 apothecaries' pounds. A cubic centimeter (C. c.) of water weighs 1 Gm. approximately, or $\frac{1}{1000}$ of a kilo, and hence 1 C. c. is usually replaced by 1 mil (which means $\frac{1}{1000}$).

Metric Capacity. For measuring fluids and the like the unit of capacity is the liter (lee-ter, French *litre*), approximately the volume of a cube 0.1 m. (about 4 in.) on an edge, and contains 1000 cubic centimeters.

The prefix most frequently used is hekto-.

1 hektoliter (hl.) = 100 l.
1 liter (l.) = 1000 C. c., nearly
= 1000 mils exactly
= about 1 quart
= the weight of 1 Kg. of water
1 mil = 0.001 l., or practically 1 C. c.

Writing the Metric Terms. In order not to confuse the metric measures with the apothecaries' measures physicians always use a zero and a decimal point in writing a prescription in the metric system, as follows:

1.0 means 1 gramme 0.01 means 1 centigramme
0.1 means 1 decigramme 0.001 means 1 milligramme

For tables of conversion, see page 26.

Problems. Metric System

1. Express 15.0 (that is 15 Gm.) as grains.

Since 1 Gm. = 15.43 gr.

15 Gm. = 15 × 15.43 gr. = 231.5 gr.

Practically, if a table is at hand, the nurse will find it advantageous to make use of it. A small table is given on page 26.

Express the following as grains, using the table if desired:

2. 20.0 Gm. **3.** 35.0 Gm. **4.** 0.7 Gm. **5.** 1.5 Gm.

6. Express gr. vj as grammes.

Since 15.43 gr. = 1.0 Gm.

1 gr. = $\frac{100}{1543}$ Gm.

and 6 gr. = $\frac{600}{1543}$ Gm. = 0.39 Gm. nearly.

Express the following as grammes:

7. gr. viij. **8.** gr. $\frac{1}{10}$. **9.** gr. ijss.

10. A physician prescribes morphine sulphate tablets of 0.015 Gm. (that is, of 15 mg.). Express this in grains.

11. A physician prescribes Pulv. Rheii gr. xxiv (that is, 24 grains of powdered rhubarb). Express this in grammes.

12. A physician prescribes Ext. Colocynthidis Comp. gr. ss (that is, ½ grain of compound extract of colocynth). Express this in the metric system.

13. In making a certain mixture it becomes necessary to have 50.0 Gm. of water. How many cubic centimeters of water must be taken?

14. In fumigating a room 2000 mils of formalin and 2000 Gm. of chlorinated lime are needed. Express these amounts in liters and kilograms. If you were not using the metric system, how many pints of the first and how many pounds (apoth.) of the second would you need?

Reduction from Metric to Apothecaries' System. For ordinary purposes these rules are sufficiently exact:

To reduce grammes to grains, multiply by 15.

Thus, 25.0 Gm. = 15 × 25.0 gr.
= 375 gr.

The multiplier 15.43236 is used where great exactness is necessary.

To reduce grammes to ounces, divide by 30.

Thus, 150 Gm. = (150 ÷ 30) oz. = 5 oz.

Reduction from Apothecaries' to Metric System. For ordinary purposes these rules are sufficiently exact:

To reduce grains to grammes, divide by 15.

Thus, 4½ gr. = (4.5 ÷ 15) Gm. = 0.3 Gm.

In case a prescription is given in other denominations, first reduce to grains. For example, 4 drams = 4 × 60 gr. = 240 gr. Then 240 ÷ 15 = 16.0 (that is, 16 Gm.).

For table of apothecaries' measures, see page 4.

To reduce grains to grammes, multiply by 0.065.

This is an alternative rule. Since 15.43 gr. = 1.0 Gm., 1 gr. = 1.0 Gm. ÷ 15.43 = 0.065 Gm.

Therefore instead of dividing by 15.43 (which is more exact than dividing by 15), we may multiply by 0.065, which is considerably easier.

To reduce ounces to grammes, multiply by 30.

Thus, 15 oz. = (30 × 15) Gm. = 450 Gm.

Approximate Equivalents. The following additional equivalents will be found convenient for use:

1 Gm. = gr. xv	1 ℥ = 30 Gm.
1 C. c. = ℿ xv	1 qt. = 1 l.
1 gr. = 0.065 Gm.	gr. $\frac{1}{60}$ = 1 mg.
1 f. ʒ = 4 Gm.	gr. ¼ = 0.015 Gm.
1 f. ℥ = 30 C. c.	gr. ss. = 0.032 Gm.

Problems. Reductions

1. A physician prescribes gr. i of calomel. Express this in the metric system.

2. A physician calls for Terpini Hydras gr. ij (that is, 2 grains of Terpin Hydrate). Express this in the metric system.

3. A physician prescribes 0.25 Gm. of suprarenal extract. Express this in the apothecaries' system.

4. A physician calls for 0.4 Gm. of camphor. Express this in the apothecaries' system.

Express the following in the metric system:

5. gr. xij **6.** gr. $\frac{1}{3}$ **7.** gr. xxiv **8.** gr. xl

9. Strophanthin gr. $\frac{1}{60}$ (that is, $\frac{1}{60}$ of a grain of strophanthin).

Express the following in the apothecaries' system:

10. 0.003 Gm. **12.** 0.04 Gm. **14.** 1.8 Gm.

11. 2.4 Gm. **13.** 3.4 Gm. **15.** 12.3 Gm.

16. Express 3.5 Kg. as grammes.

17. Express 425 Gm. as a fraction of a kilo.

18. Express 1 Kg. as grains.

19. Express 3755 mg. as grains.

20. Express gr. $\frac{1}{4}$ as grammes.

21. If you were told to give strychnine sulphate gr. $\frac{1}{30}$ to a patient, how many grammes would you give?

22. A physician orders nitroglycerine 0.00026 Gm. for a patient. How many grains will you give?

23. How many grammes in gr. x of Dover's Powder?

24. A physician wishes O i of normal salt solution and you have only a metric measuring glass. How many cubic centimeters will you use?

Per Cents and Ratios. Sometimes the strength of a solution is expressed in per cents, sometimes in common fractions, and sometimes in ratios, and hence it is necessary to be able to change quickly from one to the other.

Per cent means simply hundredths.

1% means $\frac{1}{100}$ or 0.01

2% means $\frac{2}{100}$ or 0.02

$\frac{1}{2}$% means $\frac{1}{2}$ of $\frac{1}{100}$, $\frac{1}{200}$, $\frac{5}{1000}$, or 0.005

$5\frac{1}{2}$% means $5\frac{1}{2} \times \frac{1}{100}$, $0.05\frac{1}{2}$, or 0.055

To reduce per cent to a common fraction, omit the per cent sign and write 100 for a denominator.

Thus, $6\% = \frac{6}{100}$.

To reduce per cent to a decimal fraction, omit the per cent sign and express as hundredths decimally.

Thus, $4\frac{1}{2}\% = 0.04\frac{1}{2}$, or 0.045. In reality $0.04\frac{1}{2}$ is just as properly read $4\frac{1}{2}$% as $4\frac{1}{2}$ hundredths.

The quotient of $7 \div 20$ may be written $\frac{7}{20}$ or 7 : 20, the latter being read 'the *ratio* of 7 to 20'. That is,

$$7 \div 20 = \frac{7}{20} = 7 : 20$$

To reduce per cent to a ratio, reduce to a common fraction and write this in the ratio form.

Thus $35\% = \frac{35}{100} = \frac{7}{20} = 7 : 20$.

To reduce a common fraction to per cent, divide the numerator by the denominator and write the decimal in the per cent form.

Thus, $\frac{3}{4} = 0.75 = 75\%$.

To reduce a ratio to per cent, write it as a common fraction and then reduce the fraction to the per cent form.

Thus, $25 : 35 = \frac{25}{35} = \frac{5}{7} = 0.71\frac{3}{7} = 71\frac{3}{7}\%$.

Problems. Reductions

1. A mixture of 3 quarts of alcohol to 8 quarts of water is what per cent by volume of alcohol?

There are 11 quarts of both alcohol and water. Hence the ratio of alcohol to the total is 3 : 11. Now reduce $\frac{3}{11}$ to per cent.

In this case the parts are given by volume, that is, 3 quarts of alcohol to 8 quarts of water. For our practical purposes the absorption of some of the alcohol in the water need not be considered.

2. A mixture of alcohol and water contains 30% by volume of alcohol. There are 10 l. of the mixture. Of this mixture how many liters are water?

3. The ratio by volume of alcohol to a total mixture of alcohol and water is 7 : 12. What per cent of the mixture is alcohol? What per cent is water?

4. If $\frac{2}{3}$ of a mixture of sodium bicarbonate and tr. gentian comp. is sodium bicarbonate, what is the ratio of the sodium bicarbonate to the whole mixture? of the tr. gentian comp. to the whole mixture? of the sodium bicarbonate to the tr. gentian comp.? of the tr. gentian comp. to the sodium bicarbonate?

5. In Ex. 4, how do you check the results?

To *check* a result is to find some convenient way of showing that it is correct. Since sodium bicarb. + tr. gentian = mixture, then the per cent of sodium bicarb. plus the per cent of gentian must be 100%, because the whole of anything is 100% of the thing.

6. If the weight of the first of two drugs that are mixed is $\frac{3}{4}$ of the weight of the second, each is what per cent by weight of the mixture?

7. In Ex. 6, what is the ratio of the weight of the first to the weight of the second? of the weight of the second to the weight of the first?

Review of Algebra. The amount of algebra needed for solving any problems met by nurses is very slight. It consists solely of the simple equation. Before considering a few typical equations, it is necessary to observe that $2x$ means 2 times some number which we represent by x. If $x = 7$, then $2x = 14$, $5x = 35$, $\frac{1}{3}x = \frac{7}{3} = 2\frac{1}{3}$, and 10 per cent of x is $0.10 \times 7 = 0.7$. It is also necessary to observe that *whatever is done to one side of an equation must also be done to the other side.*

1. If $3x + 5 = 47$, what is the value of x?

Subtracting 5, $3x = 42$.
Dividing by 3, $x = 14$.

2. If $\frac{3}{x+7} = \frac{1}{25}$, what is the value of x?

Multiplying these equals by $x + 7$ and by 25,
$75 = x + 7$.
Subtracting 7, $68 = x$.

Review of Proportion. Formerly, before algebra was generally understood, proportion was used to represent an equation with fractions. Thus,

$$x : 4 = 7 : 32$$

simply means $\frac{x}{4} = \frac{7}{32}$,

the latter form being much the simpler.

Multiplying by 4, $x = \frac{4 \times 7}{32} = \frac{7}{8}$.

It will thus be seen that the equation gives the same result as the old rule of multiplying the means together and dividing by one extreme to find the other extreme.

We shall use the equation instead of proportion because it is both familiar and much the simpler.

The old form $x : 4 :: 7 : 32$ has practically gone out of use in the schools.

Exercise. Algebra and Proportion

1. Solve the equation $2x + 1 = 15$. Check the work by putting the value of x in the equation and seeing that the two sides have the same value.

Subtract 1 and thus find the value of $2x$. Divide by 2 and thus find the value of x. Now put this value in the place of x in the given equation.

Solve the following equations and check the work:

2. $3x = 45$.

3. $7x = 90$.

4. $1.2x = 4.8$.

5. $1.2x = 0.48$.

6. $3\frac{2}{3}x = 17\frac{2}{3}$.

7. $0.7x = 5.6$.

8. $\frac{x}{7} = 49$.

9. $\frac{7}{x} = 49$.

10. $\frac{x+1}{5} = 13$.

11. $x + 3 = 17$.

12. $x - 9 = 18$.

13. $2x + 5 = 47$.

14. $3x - 9 = 51$.

15. $\frac{2}{3}x + 3 = 17$.

16. $\frac{2}{3}x - 5 = 35$.

17. $\frac{35}{x+1} = 7$.

18. $\frac{0.4}{x+0.4} = \frac{1}{4000}$.

19. $\frac{x}{1000} - x = \frac{1}{25}$.

20. Write the proportion $x : 17 = 3 : 51$ as an equation involving fractions, and solve the equation.

In each of the following proportions find the value of x:

21. $x : 3 = 2 : 6$.

22. $x : 5 = 3 : 2$.

23. $x : 8 = 2 : 4$.

24. $x : 500 - x = 1 : 19$.

25. $0.95 : x + 1 = 1 : 2$.

26. $3 : x + 1 = 7 : 4x - 1$.

Strength of a Solution. If we express as per cent the ratio of the weight of a substance to the weight of a solution made by adding this substance to some fluid in which it is dissolved, this per cent is called the *strength* of the solution.

Thus, a 4% silver nitrate solution is formed by dissolving 4.0 Gm. of silver nitrate in 96.0 Gm. of water.

The strength of a solution is often expressed in the form of a ratio.

Thus, a 4% solution is a solution of 4 parts of the substance to 100 parts of substance plus fluid, or of 4 to 100, or 1 to 25.

If the strength is expressed by the ratio of volumes instead of weights, pharmacists state this expressly on the bottle, the standard form being by ratio of weights. The nurse, however, will be called upon to make only approximate solutions, as for disinfectants, and *such approximate solutions are always made by volumes, simply for convenience.*

Mathematical accuracy may be sacrificed to convenience in the making of roughly approximate solutions, as in the case of ordinary disinfectants. This cannot be done, however, in the case of prescriptions involving potent drugs.

As an example of the cases in which the nurse will meet with the question of accurate computation relating to solutions, the following may be considered: A solution of sal Rochelle is marked 25 per cent. How shall the nurse give gr. xv of the drug?

Since gr. i of the solution contains 25%, or $\frac{1}{4}$, of a grain of the drug, it will take gr. iv of the solution to contain gr. i of the drug. Therefore, to have gr. xv of the drug we must take 15 × 4 gr., or 60 gr., which we write gr. lx.

Problems. Strength of a Solution

1. If gr. iij of silver nitrate are dissolved in 97 grains of water, what per cent of silver nitrate solution is formed?

2. If 4 teaspoonfuls of pure alcohol are added to 6 teaspoonfuls of water, the alcohol is then what per cent of the solution?

This will not lead to a result that is mathematically exact, first because volumes instead of weights are used; second, because the water will absorb part of the alcohol without increase of volume; and third, because water is relatively heavier than alcohol. Evidently, however, in a case of this kind these niceties need not be considered.

3. If 5 teaspoonfuls of alcohol are added to 10 teaspoonfuls of water, the alcohol is what per cent of the solution?

4. If 5 teaspoonfuls of alcohol are added to 5 teaspoonfuls of water, the alcohol is what per cent of the solution?

5. A solution of sal Rochelle is marked 20%. How shall the nurse give gr. xx of the drug?

6. How much water must be used with 10.0 Gm. of argyrol to make a solution of 1 : 10?

Express the result both by weight and by volume.

7. How much water must be used with 50.0 Gm. of magnesium sulphate to make an 8% solution?

8. How many grammes of boric acid will be needed for 2 l. of a 4% solution?

9. How many ounces of pure phenol will be required for two quarts of a 2% solution?

10. How many ounces of lysol will be needed for O xij of a 1% solution?

Table for Making 1 Liter of a Solution. If we have to make exactly 1 l. of a solution of bichloride of mercury of $\frac{1}{1000}$ or 0.1% strength from a stock solution of $\frac{1}{100}$ or 1% strength, we may first derive a formula, using $w\%$ for the weaker solution and $s\%$ for the stronger.

Let x = the number of mils of 1% solution to be used. Since the required solution is to contain $w\%$ of bichloride, and is to be exactly 1 l. or 1000 mils, we see that

$w\%$ of 1000 mils is bichloride,

and $s\%$ of x mils is also bichloride.

Therefore $w\%$ of $1000 = s\%$ of x,

and so $$x = \frac{w\% \text{ of } 1000}{s\%}.$$

In the given example, $x = \dfrac{0.1\% \text{ of } 1000}{1\%} = 100.$

That is, we put 100 mils of the 1% solution in a jar holding 1 l., and then fill the rest of the jar with water.

For the use of the following table see p. 19, Ex. 1.

Strength of Stock Solution	*25%*	*20%*	*10%*	*5%*	*4%*	*2%*	*1%*
Strength of Desired Solution	*Mils of Stock Solution to be Used*						
1 : 50, or 2%	80	100	200	400	500	1000	2000
1 : 100, or 1%	40	50	100	200	250	500	1000
1 : 200, or $\frac{1}{2}$%	20	25	50	100	125	250	500
1 : 300, or $\frac{1}{3}$%	$13\frac{1}{3}$	$16\frac{2}{3}$	$33\frac{1}{3}$	$66\frac{2}{3}$	$83\frac{1}{3}$	$166\frac{2}{3}$	$333\frac{1}{3}$
1 : 500, or $\frac{1}{5}$%	8	10	20	40	50	100	200
1 : 1000, or $\frac{1}{10}$%	4	5	10	20	25	50	1
1 : 2000, or $\frac{1}{20}$%	2	$2\frac{1}{2}$	5	10	$12\frac{1}{2}$	25	50
1 : 3000, or $\frac{1}{30}$%	$1\frac{1}{3}$	$1\frac{2}{3}$	$3\frac{1}{3}$	$6\frac{2}{3}$	$8\frac{1}{3}$	$16\frac{2}{3}$	$33\frac{1}{3}$
1 : 5000, or $\frac{1}{50}$%	$\frac{4}{5}$	1	2	4	5	10	20

Exercise. Making 1 Unit of a Solution

1. A solution of kino contains 1% of kino. How many mils of this solution should be used to make 1 l. of solution of half strength, that is, a solution of 1 : 200?

In the table on p. 18, look under 1% (right-hand column) and opposite 1 : 200 and the number 500 will be found. This shows that 500 mils of the solution of kino should be put in a liter jar, after which the jar should be filled with water, thus making a $\frac{1}{200}$ solution.

2. A solution of rhubarb contains 2% of rhubarb. How many mils of this solution should be used to make 1 l. of a solution of rhubarb 1 : 200?

3. How much of a 10% bichloride solution will be required to make a liter of a 1 : 3000 solution?

4. How much of a 5% solution of borax will be required to make a liter of a 1 : 4000 solution?

5. How much of a 10% solution of sodium chloride will be required to make a liter of a 0.1% solution?

When the table on page 18 cannot be used, work by the formula. Notice that $0.1\% = \frac{1}{10}\% = \frac{1}{1000} = 1 : 1000$.

6. A nurse has sol. quinine salicylate 50% and is told by the physician to make 10.0 Gm. of a solution 1 : 200. How much of the drug must she use?

7. How much of a 5% solution of phenol must be used in order to make 100.0 Gm. of a solution $\frac{1}{20}$?

8. How much sol. sod. bicarb. 20% must be added to water in order to make 1 l. of a solution 1 : 25?

9. How much potassium iodide 50% must be mixed with water in order to make 1 l. of a solution 1 : 5?

reduce 50 gms to 4 oz. eq.
= 97
Form

Table for Making a Weak Solution from a Stock Solution. As far as possible the nurse should make use of tables in her calculations, and checks, thus saving labor and insuring accuracy. The following table will be found of service in the making of a weak solution of stated strength from a stronger stock solution of known strength. It is based upon the formula

$$\frac{s\%}{w\%} - 1 = x$$

where $s\%$ represents the per cent of the stronger solution, $w\%$ represents the per cent of the weaker solution, x represents the number of units of water to be added, and 1 represents the given amount of stock.

The following table gives the number of units of water to be added to *one unit* of stock solution of known strength to obtain a weaker solution of desired strength.

Strength of Stock Solution	*25%*	*20%*	*10%*	*5%*	*4%*	*2%*	*1%*
Strength of Desired Solution	*Units of Water to be Added*						
1 : 50, or 2%	11½	9	4	1½	1		
1 : 100, or 1%	24	19	9	4	3	1	
1 : 200, or ½%	49	39	19	9	7	3	1
1 : 300, or ⅓%	74	59	29	14	11	5	2
1 : 500, or $\frac{1}{5}$%	124	99	49	24	19	9	4
1 : 1000, or $\frac{1}{10}$%	249	19	99	49	39	19	9
1 : 2000, or $\frac{1}{20}$%	499	399	199	99	79	39	19
1 : 3000, or $\frac{1}{30}$%	749	599	299	149	119	59	29
1 : 5000, or $\frac{1}{50}$%	1249	999	499	249	199	99	49

Exercise. Table for Solutions

1. A nurse has a stock solution of 5% phenol, or 1 : 20. How much water must be added to 1 mil of the stock solution to make a solution of 1 : 200, that is, of ½%? Solve the problem without using the table and then check by the aid of the table.

In the table, look for 5% in the top line, then for 1 : 200 or ½% in the left-hand column. The answer will be found under the 5% and to the right of the 1 : 200 or ½%; that is, the nurse must add 9 mils of water.

2. A syrup of rhubarb contains 10% fluidextract of rhubarb. How much water must be added to 1 l. of the syrup to reduce it to a 2% solution?

3. Tincture of myrrh contains 2% of myrrh. How much water must be added to 1 l. of the tincture to reduce it to a 1% solution?

4. Creosote water (Aq. creosot.) contains 1% of creosote. How much water must be added to 1 pt. of creosote water to reduce it to a solution of 1 : 300?

5. How much water must be added to 1 qt. of a 25% solution of a certain drug to reduce it to a 1% solution?

6. How much water must be added to a 20% solution of alcohol to reduce it to a solution of 1 : 100?

7. How much water must be added to O i of a 10% solution to reduce it to a 2% solution?

8. How much water must be added to 1 l. of a 2% solution of silver nitrate to reduce it to a $\frac{1}{10}$% solution?

9. How much water must be added to 1 l. of a 4% solution of bichloride of mercury to reduce it to a 1 : 5000 solution?

Using a Stock Solution of Known Strength. It frequently happens that the nurse must reduce a stock solution of known strength to a weaker solution.

For example, if a nurse has 1 pt. of 40% formalin, how much water must she add to it to reduce it to a 2% solution?

We have 0.40 pt. of formalin already and we wish to know the amount of water to be added to the 1 pt. of the present mixture so that the formalin shall be 2% of the resulting solution.

If we let x stand for the number of pints of water to be added, we have

$$\frac{0.40}{x+1} = \frac{2}{100} = \frac{1}{50}$$

Multiplying by $x + 1$ and by 50, we have

$$20 = x + 1,$$

whence

$$19 = x.$$

That is, we must add 19 pt. of water.

We should *check* this result by observing that, if we add 19 pt. to the given pint, we shall have 20 pt. Since we had 0.40 pt. of formalin to begin with, this must now be $\frac{0.40}{20}$ of the solution. But $\frac{0.40}{20} = \frac{2}{100} = 2\%$, so that we have a 2% solution as required.

In general, if we have 1 l. of a $g\%$ solution given, and an $r\%$ solution is required, we have, by the above reasoning,

$$\frac{g\%}{x+1} = r\%,$$

whence

$$g\% = r\%\,(x+1),$$

and hence

$$\frac{g\%}{r\%} - 1 = x,$$

the number of liters to be added.

The letters g (given) and r (required) make it convenient to remember this formula. See also page 20.

Problems. Changing Strength of Solution

1. How much water must be added to 1 l. of 10% creolin to make a 1% solution?

2. How much water must be added to 0.5 l. of a 3% solution of cresol to make a $\frac{1}{2}$% solution?

3. How many pints of water must be taken with 1 pt. of magnesium sulphate 1 : 2 to make a 20% solution?

4. How much water must be added to 1 l. of a 50% solution of silver nitrate to make a 15% solution?

5. Find the amount of water to be added to 0.5 l. of quinine bisulphate, 5% solution, to make a $\frac{1}{5}$% solution.

Exs. 6–15 involve the principle given on page 18.

Find the number of mils of solutions of the following strengths that must be used to make 1 l. of the required solution:

	6.	7.	8.	9.	10.
Given Strength	20%	10%	5%	1%	25 : 100
Required Strength	2%	2%	1%	$\frac{1}{30}$%	1 : 500

11. How many mils of 20% ammonium bromide should be used to make 1 l. of a 10% solution?

12. How many mils of a 20% solution of sodium acetate should be used to make 1 l. of a 2% solution?

13. How many mils of a 10% solution of zinc sulphate should be used to make 1 l. of a 1% solution?

14. How many mils of a 4% solution of boric acid should be used to make 1 l. of a $\frac{1}{2}$% solution?

15. How many mils of a 15% solution of cocaine will be needed to make 50 C. c. of a 1% solution?

Modification of Dosage for Children. The following rule is often used in the calculation of doses for infants under 1 yr. of age:

Infant dose $= \frac{m}{150}$ of adult dose, where m stands for the number of months in the infant's age.

Thus, if the adult dose of a certain drug is f. ℥i, the dose for an infant 6 mo. old is $\frac{6}{150}$ of f. ℥ i, or $\frac{1}{25}$ of a fluidram, which is between 2 and 3 drops.

The following rule is often used in the calculation of doses for children from 1 yr. to 12 yr. old:

$$\text{Child dose} = \frac{y}{y + 12} \text{ of adult dose,}$$

where y stands for the number of years in the child's age.

Thus, if the adult dose of a certain drug is 0.5 Gm., the dose for a child 4 yr. old is $\frac{4}{16}$ of 0.5 Gm., or $\frac{1}{4}$ of $\frac{1}{2}$ Gm., or $\frac{1}{8}$ Gm., or, as ordinarily written, 0.125 Gm.

Modification of Tablet Doses. If the nurse has strychnine tablets of gr. $\frac{1}{20}$, gr. $\frac{1}{40}$, and gr. $\frac{1}{60}$, and a dose of gr. $\frac{1}{30}$ is prescribed, it becomes necessary to give a part of a larger tablet. For example, if you wish to give $\frac{1}{30}$ of a grain of strychnine, and have gr. $\frac{1}{20}$ tablets on hand, find what part the gr. $\frac{1}{30}$ is of gr. $\frac{1}{20}$.

Since $\frac{1}{30} \div \frac{1}{20} = \frac{1}{30} \times 20 = \frac{2}{3}$, we see that gr. $\frac{1}{30}$ = $\frac{2}{3}$ of gr. $\frac{1}{20}$; and to give the required dose you would give $\frac{2}{3}$ of the gr. $\frac{1}{20}$ tablet. The simplest way to do this exactly is to dissolve the gr. $\frac{1}{20}$ tablet in such a number of minims of water that $\frac{2}{3}$ can easily be taken, as for instance, 12 minims. Taking $\frac{2}{3}$ of 12 minims, or 8 minims, the required dose can be quickly given.

A practical working rule for this is: *Divide the required weight by the weight of the tablet on hand.*

Exercise. Fractional Doses

1. Using the formula $\frac{m}{150}$ find how much morphine may be given an infant 9 months old, if the adult dose is 0.01 Gm.

2. Using the formula $\frac{y}{y + 12}$, find from Ex. 1 the amount of morphine that may be given a child 9 years old.

3. If the adult dose of strychnine is gr. $\frac{1}{40}$ what is the dose for a child $3\frac{1}{2}$ years old?

4. If the adult dose of Fowler's Solution is 3 ♏, what is the dose for a child 6 years old?

State which fraction in each of the following pairs is the larger:

5. $\frac{1}{10}$, $\frac{1}{20}$. **6.** $\frac{1}{10}$, $\frac{3}{20}$. **7.** $\frac{1}{20}$, $\frac{1}{60}$. **8.** $\frac{1}{20}$, $\frac{5}{32}$. **9.** $\frac{1}{16}$, $\frac{3}{64}$.

Arrange the fractions in order of size, in each of the following cases, beginning with the smallest:

10. $\frac{3}{20}$, $\frac{1}{10}$, $\frac{1}{30}$. **11.** $\frac{1}{20}$, $\frac{1}{60}$, $\frac{1}{16}$. **12.** $\frac{3}{4}$, 0.6, $\frac{11}{20}$.

13. If you have tablets of gr. $\frac{1}{60}$ on hand, how would you give gr. $\frac{1}{30}$?

14. If you have tablets of 0.4 Gm. on hand, how would you give 0.3 Gm.? 0.2 Gm.? 8 Gm.?

The solution of such a problem shows the great superiority of the metric system in medical prescriptions.

15. If ♏ xx of a solution contain gr. $\frac{1}{4}$ of morphine sulphate, how many minims would you need to give gr. $\frac{1}{12}$ of morphine sulphate?

Reduction Tables. The nurse will find it convenient to make use of the reduction tables given on pages 26–28.

METRIC AND APOTHECARIES' TABLES

Metric	*Grains*	*Drams*	*Ounces*	*Pounds*
1 milligramme (mg.), 0.001 Gm.	0.01543	0.0003		
1 centigramme (cg.), 0.01 Gm.	0.15432	0.0026	0.0003	
1 decigramme (dg.), 0.1 Gm.	1.5432	0.0257	0.0032	0.00027
1 gramme (Gm.)	15.4323	0.257	0.0321	0.00270
1 kilogramme (Kg.) 1000 Gm.	15,432.356	257.206	32.1508	2.6792

The following approximate equivalents may be used in ordinary cases where great exactness is not required:

1 mg. = 0.001 Gm. = gr. $\frac{1}{64}$
1 cg. = 0.01 Gm. = gr. $\frac{1}{6}$
1 dg. = 0.1 Gm. = gr.jss = gr. $1\frac{1}{2}$.
1 Gm. = gr. $15\frac{1}{2}$
1 Kg. = ℥ 32 = $2\frac{2}{3}$ lb. Apoth.

APPROXIMATE EQUIVALENTS

Grammes	*Written*	*Grains*
2	2.0	30
1	1.0	15
0.6	0.6	10
0.3	0.3	5
0.2	0.2	3
0.1	0.1	$1\frac{1}{2}$
0.06	0.06	1
0.03	0.03	$\frac{1}{2}$
0.015	0.015	$\frac{1}{4}$
0.008	0.008	$\frac{1}{8}$
0.004	0.004	$\frac{1}{16}$

TABLES OF TEMPERATURE

C.	F.	C.	F.	F.	C.
0	32	23	73.4	90	32.2
2	35.6	24	75.2	91	32.8
4	39.2	25	77	92	33.3
5	41	26	78.8	93	33.9
6	42.8	27	80.6	94	34.4
7	44.6	28	82.4	95	35
8	46.4	29	84.2	96	35.6
9	48.2	30	86	97	37.1
10	50	31	87.8	98	36.7
11	51.8	32	89.6	99	37.2
12	53.6	33	91.4	100	37.8
13	55.4	34	93.2	101	38.3
14	57.2	35	95	102	38.9
15	59	36	96.8	103	39.4
16	60.8	37	98.6	104	40
17	62.6	38	100.4	105	40.6
18	64.4	39	102.2	106	41.1
19	66.2	40	104.	107	41.7
20	68	41	105.8	108	41.2
21	69.8	42	107.6	109	42.8
22	71.6	43	109.4	110	43.3

Centigrade readings are usually given in decimals, while Fahrenheit readings are given either in decimals or in common fractions.

The above table is made up from the relation of the Centigrade to the Fahrenheit thermometer, as follows:

n degrees Centigrade $= \left(\frac{9n}{5} + 32\right)$ degrees Fahrenheit,

n degrees Fahrenheit $= \frac{5}{9}\left(n - 32\right)$ degrees Centigrade.

Problems. Review Exercise

1. A patient's temperature is 99.5° F. Express this on the Centigrade scale.

2. A patient's temperature is 38.9° C. Express this on the Fahrenheit scale.

3. Express 7.0 Gm. in grains, correct to five significant figures.

While the nurse will not be called upon for such a degree of accuracy, the problem is given as an exercise in the use of the tables on page 26.

4. A physician prescribes 3.0 Gm. of a certain drug. Express this amount in grains.

5. A physician prescribes $1\frac{1}{2}$ grains of a certain drug. Express this amount in grammes.

6. Write a simple rule for converting ratio to per cent.

7. Write a simple rule for converting per cent to ratio.

8. Write rules for determining the strength of a solution, both in ratio and in per cent, when the amount of the solution and the amount of the drug are given.

9. Write a rule for determining the amount of a drug needed to make a given amount of a solution of given strength.

10. Write a rule for determining the amount of a stock solution needed to make a weaker solution of given strength: (a) When the strength is expressed in ratio, (b) When the strength is expressed in per cent, (c) When the strength is expressed as a common fraction.

11. In the medicine cabinet is a 50% solution of magnesium sulphate. How much of this solution must you give when the physician has ordered a dose of mag. sulph. ℥ vi?

12. The stock solution of bichloride of mercury being 4%, how will you proceed to make up O iv of a 1 : 2000 solution?

13. How much carbolic acid is needed to make 1 pt. of a 3% solution? Solve (a) by first reducing to the metric system and (b) by using only the apothecaries' system.

14. How much potassium permanganate must be used to make 1 Kg. of a 4% solution?

15. How much water must be added to 1 qt. of a 20% solution of ammonium carbonate to reduce it to a 10% solution?

16. How much water must be added to 1 pt. of a 30% solution of potassium bromide to reduce it to a 20% solution?

17. A tablet of bichloride of mercury weighs 10 grains. How much water must be used with it to make a solution of 1 : 3000?

18. If the stock solution of phenol is 1 : 20, how much water must be added to 1 mil of this solution to make a 1% solution?

19. In Ex. 18, how much water must be added to 5 mils of the solution 1 : 20 to make a solution 1 : 200? to make a solution of 1%?

Abbreviations used in Prescriptions. The abbreviations used in prescriptions include the one used in the superscription; those used in the inscription, or the names and amounts of the ingredients; those used in the subscription, giving the directions to the pharmacist; and those used in the signature, giving the directions which the pharmacist is to write on the label.

In the superscription

℞ = recipe, take

In the inscription

The ingredients in their Latin names, such as

Aq. = aqua, water
destil. = destillata, distilled

In the subscription and signature

M.	= misce, mix	s̄.	= sine, without
pil.	= pilula, pill	stat.	= statim, at once
āā	= ana, of each	c̄.	= cum, with
ad	= to, up to	o. h.	= omne hora, hourly
b. i. d.	= bis in die, twice daily	s. o. s.	= si opus sit, if necessary
t. i. d.	= ter in die, thrice daily	a. c.	= ante cibum, before meals
o. m.	= omne mane, every morning	p. c.	= post cibum, after meals
o. n.	= omne nocte, every night	q. h.	= quaqua hora, hourly
p. r. n.	= pro re nata, when required	Sig.	= signa, write on label
q. s.	= quantum sufficit, as much as necessary	ne rep.	= ne repetatur, not to be refilled (prescription)

Answers to the Problems. Students may check their solutions of problems by using the following answers:

Page 5. **1.** $\frac{1}{12}$. **2.** 2 ounces. **3.** 8 minims. **4.** $\frac{1}{8}$ fluidram. **5.** 3 fluidrams. **6.** 24 minims. **7.** 18 drams. **8.** 4 ounces. **9.** 30 grains. **10.** 44 grains. **11.** $2\frac{1}{2}$ ounces.

Page 7. **4.** 11.3 mi. **5.** 15.7 mi. **6.** 5.4 mi. **7.** 110. **8.** 90.9. **9.** 100 mm. **10.** 66 ft. by 132 ft.

Page 9. **2.** 308.6 gr. **3.** 540.1 gr. **4.** 10.8 gr. **5.** 23.1 gr. **7.** 0.52 Gm. **8.** 0.006 Gm. **9.** 0.16 Gm. **10.** 0.2 gr. **11.** 1.56 Gm. **12.** 0.032 Gm. **13.** 50. **14.** 2 l.; 2 Kg.; 4 pt.; 5.34 lb.

Page 11. **1.** 0.065 Gm. **2.** 0.13 Gm. **3.** 3.75 gr. **4.** 6 gr. **5.** 0.78 Gm. **6.** 0.022 Gm. **7.** 1.56 Gm. **8.** 2.6 Gm. **9.** 1 mg. **10.** 0.045 gr. **11.** 36 gr. **12.** 0.6 gr. **13.** 51 gr. **14.** 27 gr. **15.** 184.5 gr. **16.** 3500 Gm. **17.** $\frac{17}{40}$ Kg. **18.** 15,000 gr. **19.** 56.3 gr. **20.** 0.015 Gm. **21.** 0.00216. **22.** 0.0039. **23.** 0.65. **24.** 500.

Page 13. **1.** $27\frac{3}{11}\%$. **2.** 7. **3.** $58\frac{1}{3}\%$; $41\frac{2}{3}\%$. **4.** 2 : 3; 1 : 3; 2 : 1; 1 : 2. **6.** $42\frac{6}{7}\%$; $57\frac{1}{7}\%$. **7.** 3 : 4; 4 : 3.

Page 15. **1.** 7. **2.** 15. **3.** $12\frac{6}{7}$. **4.** 4. **5.** 0.4. **6.** $4\frac{9}{11}$. **7.** 8. **8.** 343. **9.** $\frac{1}{7}$. **10.** 64. **11.** 14. **12.** 27. **13.** 21. **14.** 20. **15.** 21. **16.** 60. **17.** 4. **18.** 1599.6. **19.** $-\frac{40}{999}$. **20.** $\frac{x}{17} = \frac{3}{51}$; 1. **21.** 1. **22.** $7\frac{1}{2}$. **23.** 4. **24.** 25. **25.** 0.9. **26.** 2.

Page 17. **1.** 3%. **2.** 40%. **3.** $33\frac{1}{3}\%$. **4.** 50%. **5.** 100 gr. **6.** 90 Gm.; 90 C.c., or $\frac{9}{100}$ l. **7.** 575 Gm. **8.** 80. **9.** 1.28. **10.** 1.92.

Page 19. **2.** 250. **3.** $3\frac{1}{3}$ mils. **4.** 5 mils. **5.** 10 mils. **6.** $\frac{1}{10}$ mil. **7.** 100 mils. **8.** 200 mils. **9.** 400 mils.

Page 21. **1.** 9 mils. **2.** 4 l. **3.** 1 l. **4.** 2 pt. **5.** 24 qt. **6.** 19. **7.** 4 O. **8.** 19 l. **9.** 199 l.

Page 23. **1.** 9 l. **2.** 2.5 l. **3.** $1\frac{1}{2}$ pt. **4.** $2\frac{1}{2}$ l. **5.** 12 l. **6.** 100. **7.** 200. **8.** 200. **9.** $33\frac{1}{3}$. **10.** 8. **11.** 500. **12.** 100. **13.** 100. **14.** 125. **15.** $3\frac{1}{3}$.

Page 25. **1.** 0.0006 Gm. **2.** $0.004\frac{2}{7}$ Gm. **3.** $\frac{7}{1240}$ gr. **4.** 1 minim. **5.** $\frac{1}{10}$. **6.** $\frac{3}{20}$. **7.** $\frac{1}{20}$. **8.** $\frac{5}{32}$. **9.** $\frac{1}{16}$. **10.** $\frac{1}{30}$, $\frac{1}{10}$, $\frac{3}{20}$. **11.** $\frac{1}{60}$, $\frac{1}{20}$, $\frac{1}{16}$. **12.** $\frac{11}{20}$, 0.6, $\frac{3}{4}$. **13.** Give 2. **14.** Give $\frac{3}{4}$; $\frac{1}{2}$; 20. **15.** $6\frac{2}{3}$ minims.

Page 28. **1.** 37.5° C. **2.** 102.02° F. **3.** 108.03 gr. **4.** 46.2969 gr. **5.** 0.1 Gm., or 0.0975 Gm.

Page 29. **11.** $12\frac{3}{5}$. **13.** 15 C.c.; 230.4 minims. **14.** 40 Gm. **15.** 1 qt. **16.** $\frac{1}{2}$ pt. **17.** 29,900 minims. **18.** 4 mils. **19.** 45 mils; 20 mils.

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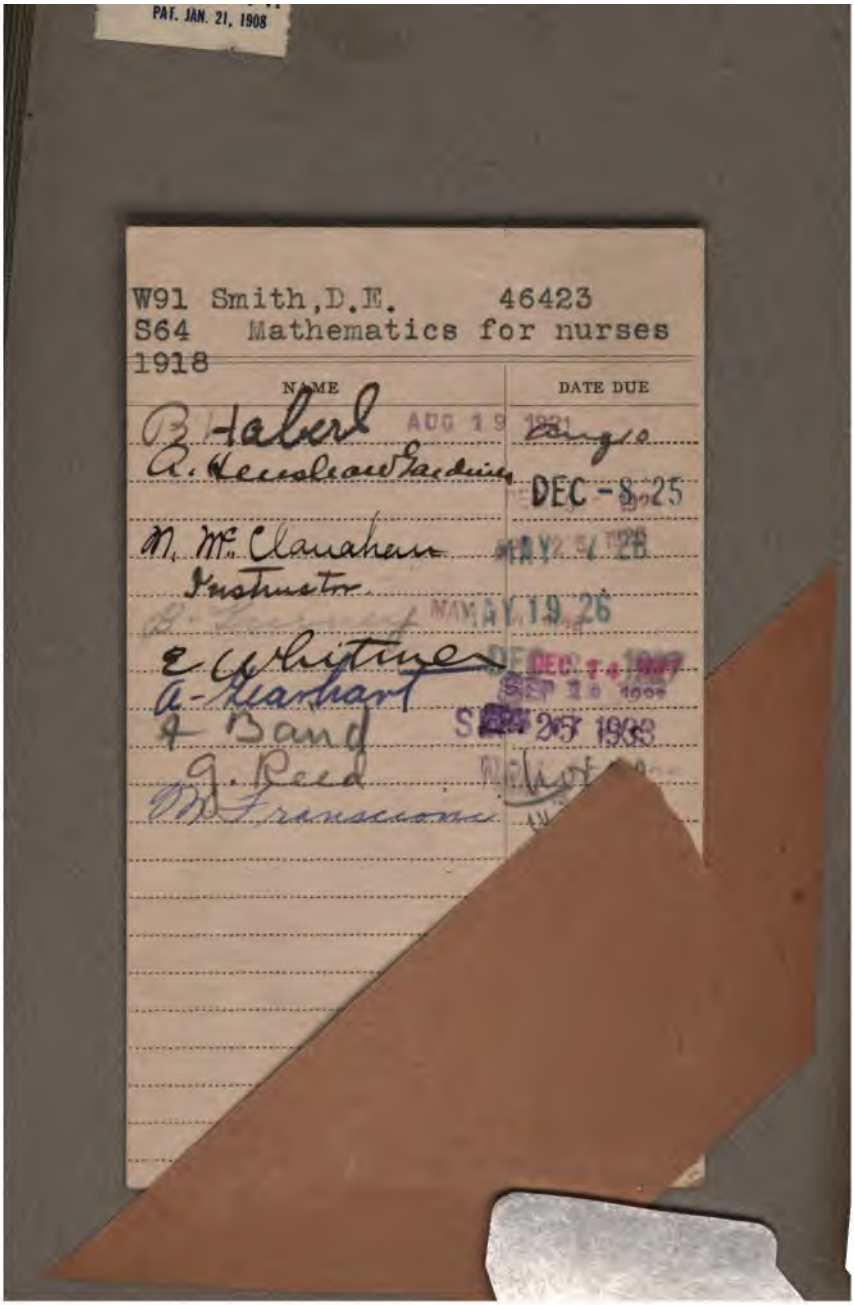
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